Knowledge, attitude and practice associated with brucellosis in occupational risk groups in China

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ความรู้ ทัศนคติ และการปฏิบัติที่เกี่ยวข้องกับโรคบลูเซลโลซิสที่ติดต่อในกลุ่มอาชีพเสี่ยงในประเทศจีน

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ฉวนกัง ซู : ความรู้ ทัศนคติ และการปฏิบัติที่เกี่ยวข้องกับโรคบลูเซลโลซิสที่ติดต่อในกลุ่มอาชีพเสี่ยงในประเทศจีน. (Knowledge, attitude and practice associated with brucellosis in occupational risk groups in China) อ.ที่ปรึกษาหลัก : ศ. ดร.อลงกร อมรศิลป์, อ.ที่ปรึกษาร่วม : ผศ. ดร.สหฤทัย เจียมศรีพงษ์

การศึกษานี้มีวัตถุประสงค์เพื่อวิเคราะห์สถานการณ์ความรู้ เจตคติ และการปฏิบัติตนของเกษตรกรผู้เลี้ยงแกะและแพะ รวมทั้งเจ้าหน้าที่ดูแลสุขภาพสัตว์ในชุมชนที่มีต่อการป้องกันและควบคุมโรคแท้งติดต่อ เกษตรกรผู้เลี้ยงแกะและแพะทั้งสิ้นจำนวน 1,067 รายและเจ้าหน้าที่ดูแลสุขภาพสัตว์ในชุมชน 401 ราย จาก 7 จังหวัดในประเทศจีน เข้าร่วมในการศึกษานี้ ตั้งแต่ปี พ.ศ. 2560 ถึงปี พ.ศ. 2561 แบบสอบถามทั้งสองชุดจะใช้เพื่อระบุลักษณะของประชากร และความรู้ เจตคติ และการปฏิบัติตนที่เกี่ยวข้องกับโรคแท้งติดต่อ สถิติเชิงพรรณนาใช้ในการสรุปลักษณะทางประชากรศาสตร์และความรู้ เจตคติ และการปฏิบัติตน การทดสอบ Mann-Whitney U ใช้ในการวิเคราะห์ปัจจัยเสี่ยงที่เกี่ยวข้องกับความรู้ เจตคติ และการปฏิบัติตนของผู้ตอบแบบสอบถาม โดยรวมความตระหนักในการป้องกันและควบคุมโรคแท้งติดต่อของเกษตรกรและเจ้าหน้าที่สาธารณสุข คือ 64.2% และ 80.1% ตามลำดับ ประมาณ 17.2% ของเกษตรกรและ 12.2% ของเจ้าหน้าที่สาธารณสุข ไม่เคยได้ยินเกี่ยวกับโรคแท้งติดต่อ เกษตรกร (75.8%) และเจ้าหน้าที่สาธารณสุข (83.8%) มีทัศนคติที่ดีต่อการป้องกันและควบคุมโรคแท้งติดต่อ แต่ทัศนคติที่ดีไม่สอดคล้องกับแนวทางปฏิบัติที่เหมาะสม เกษตรเพียงครึ่งหนึ่งมีแนวปฏิบัติที่ดี เกษตรกรที่อาศัยอยู่ในพื้นที่ภาคเหนือ มีอายุน้อยกว่า 45 ปี มีระดับการศึกษาสูงกว่ามัธยมศึกษาตอนต้น มีประสบการณ์ในการทำงานน้อยกว่า 5 ปี และแกะหรือแพะในฟาร์มเคยติดบรูเซลลา มีคะแนนของความรู้ เจตคติ และการปฏิบัติตนสูงกว่าคนอื่นอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) เจ้าหน้าที่สาธารณสุขที่มีการศึกษาต่ำกว่า จะมีคะแนนความรู้ เจตคติ และการปฏิบัติตน ต่ำกว่าผู้ที่มีการศึกษาระดับอุดมศึกษา ($p < 0.01$) แม้ว่ารัฐบาลได้ดำเนินการป้องกันและควบคุมโรคแท้งติดต่อแล้ว แต่การศึกษานี้ระบุว่าการป้องกันและควบคุมโรคแท้งติดต่อยังไม่เป็นที่น่าพอใจ ผู้เข้าร่วมส่วนใหญ่ได้รับข้อมูลโรคแท้งติดต่อจากผู้เชี่ยวชาญและสื่อประชาสัมพันธ์แบบเดิม ซึ่งอาจจะไม่ถูกต้องและไม่มีประสิทธิภาพ ผลการศึกษานี้ชี้ให้เห็นถึงความจำเป็นในการพัฒนาสื่อที่เหมาะสมและวิธีการลดผลกระทบต่อปศุสัตว์และครอบครัว ความรู้ที่เหมาะสมและการเข้าถึงสื่อประชาสัมพันธ์สามารถช่วยปรับปรุงความรู้ เจตคติ และการปฏิบัติตนต่อควบคุมป้องกันโรคแท้งติดต่อได้

สาขาวิชา	สัตวแพทยสาธารณสุข	ลายมือชื่อนิสิต .....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....
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Quangang Xu : Knowledge, attitude and practice associated with brucellosis in occupational risk groups in China. Advisor: Prof. ALONGKORN AMONSIN, D.V.M., Ph.D. Co-advisor: Asst. Prof. SAHARUETAI JEAMSRIPONG, D.V.M., M.V.P.M., Ph.D.

This study aimed to analyze the situation of knowledge, attitude, and practice (KAP) of sheep and goat farmers and community animal health staff towards the prevention and control of brucellosis. A total of 1,067 sheep and goat farmers and 401 community animal health staff from seven provinces in China were participated in this study from 2017 to 2018. Two structured questionnaire were used to examine demographic characteristics and KAP related to brucellosis. Descriptive statistics were used for demographic characteristics and KAP. Mann-Whitney U test was used to analyze the potential risk factors associated with KAP among participants. The overall awareness of brucellosis prevention and control of the farmers and animal health staff was 64.2% and 80.1%, respectively. Approximately, 17.2% of the farmers and 12.2% of the animal health staff had never heard of brucellosis. Farmers (75.8%) and animal health staff (83.8%) had positive attitude to brucellosis prevention and control, but the good attitude did not correspond to proper practices. Only half of the farmers had good practice. The farmers, who resided in northern areas had age less than 45 years, education higher than junior high school, experienced of livestock farming less than 5 years and their sheep or goat ever infected with brucellosis, had higher KAP scores than others ($p < 0.05$). Animal health staffs, who had lower education, had lower KAP scores than those had higher education ($p < 0.01$). This study addressed that the previous prevention and control of brucellosis was unsatisfactory. Most of participants obtained information of brucellosis from experts and traditional publicity materials leading to low precision and low efficiency. Our results highlighted the need for the development of suitable educational materials to ensure herders were aware of the disease and ways to minimize its impact on their livestock and their families. Appropriate and accessibility of publicity knowledge could help to improve KAP for f prevention and control of brucellosis.

Field of Study:	Veterinary Public Health	Student's Signature .....
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		Co-advisor's Signature .....

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Abbreviations

APHIS	Animal and Plant Health Inspection Service
CADC	China Animal Disease Prevention and Control Center
CAHEC	China Animal Health and Epidemiology Center
DLD	Department of Livestock Development
FAO	Food and Agriculture Organization of the United Nations
KAP	Knowledge, Attitude and Practice
MARA	Ministry of Agriculture and Rural Affairs
NBS	National Bureau of Statistics
OIE	World Organization for Animal Health
USDA	United States Department of Agriculture
WHO	World Health Organization

Chapter I Introduction

Brucellosis is a highly contagious zoonosis of a wide range of terrestrial animals and humans (Radostits et al., 2007). This disease can cause by several species of the genus *Brucella*, mainly *B. abortus*, *B. Suis*, and *B. melitensis* (Cloeckaert et al., 2002). Infection with *Brucella* spp. in cattle is usually caused by *B. abortus*, while *B. suis* mainly affects on swine and cattle production. Sheep and goats are common reservoirs for *B. melitensis*. *B. abortus, B. suis*. Among *Brucella* species, *B. melitensis* are highly pathogenic bacteria for humans (OIE, 2008).

Brucella spp. is mainly distributed in the Mediterranean basin, the Arabian gulf, the Indian subcontinent, Mexico, and Central and South America (Mantur et al., 2007). In some endemic areas, the incidence of brucellosis reported in humans varies from less than 0.01 to greater than 200 per 100,000 human population (Boschiroli et al., 2001). It is estimated that the actual number of *Brucella* cases in animals is approximately 25 times higher than those from human cases annually (Doganay and Aygen, 2003).

Brucellosis has caused huge economic impact and serious public health threats in many developing countries because of the high morbidity in both humans and animals (Colmenero et al., 1996). The annual losses of brucellosis affecting in bovine due to brucellosis is estimated at 600 million USD in Latin America (Seleem et al., 2010). In the United States, the estimated annual cost of milk reduction and abortion of livestock due to brucellosis was 400 million USD and 575,605 USD in Nigeria (Ajogi, 1998; Acha and Szyfres, 2001). Despite a high burden of brucellosis on animal production and human health in many parts of the world, the World Health Organization (WHO), Food and Agriculture Organization (FAO) and World Organization for Animal Health (OIE) consider brucellosis as a neglected zoonosis (WHO, 2010).

Humans usually get infected with *Brucella* spp. through direct contact with infected animals or ingestion of contaminated raw milk, unpasteurized dairy products, undercooked meat, and animal by products from infected animals (Garcell et al., 2016). As a result, individuals who have occupational contact with livestock in endemic areas of brucellosis (e.g., livestock owners, abattoir workers, shepherds, and

veterinarians) are at a high-risk group. The clinical signs of brucellosis in human are non-specific. The main clinical symptoms, including fever (over 38.5 °C), sweats, anorexia, malaise, headache, backache, and arthralgia. Some chronic cases may develop arthritis, sacroiliitis, spondylitis, osteomyelitis, and endocarditis (Seleem et al., 2010). In livestock, brucellosis mainly causes a decline of production, which has been a serious impact on the livelihood and economic burden of farmers. The impact of brucellosis has occurred in food-producing animals mainly found in developing countries. For female livestock, abortions often occur during late term pregnancy. Placenta retention and metritis are predominant clinical signs that usually found after the abortion. In male livestock, the main clinical symptoms are orchitis and epididymitis (OIE, 2019).

In mainland China, the first report of human brucellosis has announced since 1905, and the incidence rate of human brucellosis was considered severe with interquartile range between 0.42 to 1.0 cases per 100,000 residents during 1955-1978. Then, the significantly decline of brucellosis cases were examined in 1979-1994. Unfortunately, the brucellosis in China has re-emerged and has increasingly concerned since 1995 (Lai et al., 2017).

Meanwhile, the number of livestock infected with *Brucella* spp. also increased significantly in the past decade. In 2018, brucellosis has been reported throughout 31 provinces in mainland China (Guan et al., 2018). It has been reported that *B. melitensis* was associated with human brucellosis outbreaks, and the main sources of the infection were originated from sheep and goats (Ran et al., 2018). The Chinese government has been implemented comprehensive prevention and control measures of brucellosis, which has been made against brucellosis in the country. Nevertheless, brucellosis is still a major threat to public health and veterinary public health, and significant efforts are needed to achieve the goal of controlling brucellosis both in human and livestock (Deqiu et al., 2002).

In general, the prevention and control of brucellosis in livestock is the key to prevent the human brucellosis. Strategies to control and prevent brucellosis included vaccination, removing of infected animals from herd, and improving sanitation and hygienic practices, etc. The stringent measures of removal infected

animals from herds can effectively minimize the risk of introduction of infected animals to disease-free herds (FAO, 2009). Basic personal hygienic practices such as proper handling of birth materials with protection and washing hands after working can significantly reduce the risk of brucellosis transmission from livestock to humans (Tempia et al., 2019).

It has been suggested that knowledge and behavior of livestock owners must be taken into account in the implementation of the prevention and control of brucellosis (Tiongco et al., 2012; Kansiime et al., 2014). Lack of sufficient knowledge on disease transmission would result in the increased risk of disease infection, and enhanced disease circulation in animal population (Tebug, 2013). Knowledge, attitudes, and practices (KAP) is the most common method that has been wildly used to explain how personal knowledge and beliefs influence healthy behavioral changes (WHO, 2008). Furthermore, KAP are very useful tool for decision makers and policy developers to effectively implement on prevention and control strategies for zoonotic diseases (Xiang et al., 2010). Therefore, this study aimed to analyze the situation of KAP towards the prevention and control of brucellosis from sheep and goat farmers and community animal health staff. This study is expected to provide technical support for future health intervention and disease control and prevention in both humans and animals.

Chapter II Literature review

1. General characteristics of brucellosis

Brucellosis is an important zoonosis caused by organisms in the genus *Brucella* spp., which is naturally transmitted between humans and other vertebrates. The *Brucella* spp. is a Gram-negative bacterium, non-motile, non-spore forming, rod to coccoid shape and encapsulated in cells. *Brucella* has strong viability in the external environment. In conditions of drying, low temperatures, or high humidity, these bacteria could still survive. The persistence of *Brucella* spp. is also found in water, aborted fetuses, wool, equipment, and clothing for several months. However, the bacteria are very sensitive to disinfectants, iodophor, phenolic soap, and caustic soda, therefore these bacteria can be eliminated when using acidity condition, which was below pH 3.5-4 (Corbel, 1997).

Currently, nine species of *Brucella*, including *B. abortus*, *B. melitensis*, *B. suis*, *B. ovis*, *B. canis*, *B. neotomae*, *B. microti*, *B. ceti* and *B. pinnipedialis* have been reported. In general, *B. abortus*, *B. melitensis*, *B. suis*, and *B. ovis* are mainly found in livestock. *Brucella* spp. are considered as a host specific pathogen such as *B. canis* in dogs, *B. neotomae* and *B. microti* in wild rodents, and *B. ceti* and *B. pinnipedialis* in marine mammals. *B. melitensis*, *B. abortus*, *B. suis* and *B. canis* are significance bacterial species that can cause human infection. However, *B. melitensis* is the most pathogenic strain that has been reported in humans (Blasco and Molina-Flores, 2011).

2. Brucellosis in livestock

2.1 Occurrence of brucellosis in livestock

Although brucellosis is widely distributed worldwide, most developed countries have well control and prevention strategies. However, the animal cases of brucellosis still occur frequently in Africa, Asia, South and Central America, and the Mediterranean regions. In North America, the Canadian national cattle herd was declared brucellosis-free in 1985, and all 50 states in the U.S. were simultaneously designated brucellosis class free in 2008 (B Lopes et al., 2010). In South America, Africa, and Asia, the prevalence of brucellosis varies widely from country to country.

In Santa Catarina state of Brazil, the prevalence of bovine brucellosis observed among infected herds was 0.9% with 95% confidence interval at 0.3-2.1, and infected animals was 1.2% with 95% CI at 0.1-5.0 (Baumgarten et al., 2016). A comparative study in rural Uganda revealed that the occurrence of *Brucella* was examined in cattle serum (14%), bovine milk (29%), and goat serum (17%) (Miller et al., 2016). In Ghana, the overall prevalence of brucellosis in cattle is 2.9% in an individual level and 35.3% in a herd level (Folitse et al., 2014). In 2013, the Department of Livestock Development (DLD) of Thailand reported sero-prevalence of brucellosis was 12.1% at herd level for both goats and sheep, and 1.4% for goats and 1.6% for sheep at individual animal level (Sagarasaeranee et al., 2017). The overall prevalence in bovine brucellosis in India was approximately 12.0%. (Deka et al., 2018). In Pakistan, the prevalence of brucellosis was found 14.5% in sheep and goat, and the prevalence in female and male cattle were 10.6% and 21.1%, respectively (Suthar et al., 2018).

2.2 Disease transmission

The pathway of *Brucella* transmission is diverse since these bacteria can be found in diverse sectors, including human, animals, and the environment. In livestock, the animals usually get infected by contact with the contaminated placenta, fetus, fetal fluids, and vaginal discharges from infected animals. Since *Brucella* species can be found in semen, male livestock can shed these bacteria for long periods. Therefore, venereal transmission is a possible route of brucellosis. *Brucella* can be spread through fomites, feed, and water. In addition, the disease may also spread when wild animals or animals from an affected herd are introduced to the brucellosis free herds (APHIS, 2019).

2.3 Clinical symptoms

Brucellosis mainly causes a decline of production in livestock. For female livestock, abortion often occurs during late pregnancy with placenta retention and metritis (Acha and Szyfres, 2001). Sometimes, chronic cases of brucellosis lead to sterility. In male livestock, the main symptoms of brucellosis are orchitis and epididymitis. At herd level, the main effect of brucellosis is characterized by an

increase in lamb/kid mortality with a low percentage of weaning, a decrease in flock or herd fertility, a decrease on milk production and an increase culling of males due to the persistence of chronic lesions on reproductive organs (Commission, 2001).

3. Brucellosis in humans

Brucellosis, popularly called Malta fever, undulant fever, or Bang's disease, is listed by WHO as a neglected zoonosis (WHO, 2006). Humans usually get infected with *Brucella* spp. by ingesting contamination materials or close contact with infected tissues. Contact with animal abortion products, ingestion of unpasteurized dairy products, or uncooked meat are the common sources of human infection of *Brucella* (Zhang et al., 2014). *Brucella* also can transmit in aerosols in the laboratory and abattoirs (Mangalgi et al., 2016). Live attenuated vaccines against *Brucella* in livestock animals are considered as a potential source of brucellosis human. Unrestricted used of personal protective gears when vaccinating livestock is possible to cause human infection (Ashford et al., 2004). The transmission between person to person contact can occur, but it is it reported in a very rare case, (Pappas et al., 2005).

Brucellosis causes many clinical symptoms in humans, including fever, constitutional appearance, bone and joint, neuropsychiatric symptoms, and gastrointestinal tracts. Fever is the most common clinical sign reported at 80-100%. Constitutional symptoms of brucellosis are very common, including fatigue, anorexia, weakness, asthenia, and malaise. Bone and joint symptoms include low back pain, arthralgia, and joint swelling. Neuropsychiatric symptoms include headache, depression, and fatigue. The symptoms of gastrointestinal tracts include constipation, abdominal pain, vomiting, and diarrhea (Sakran et al., 2006). In general, the mortality rate of human brucellosis is relatively low, but the impact of disabling from chronic feature imposed a heavy burden in rural communities (Jackson et al., 2007). Sometimes, brucellosis in humans may be misdiagnosed and under-detected leading to widely observed undetected cases globally (Corbel, 2006).

4. Situation of brucellosis in China

In mainland China, human brucellosis was first documented on two foreigners in Shanghai in 1905 (Boone, 1905). In 1916, the first case of brucellosis was reported from Fujian using serologic tests, which is a definitive diagnosis (Maxwell, 1916). In 1925, *Brucella* spp. was first isolated from a foreigner and his goats (Lim, 1925). Subsequently, the first human case infected in a laboratory setting was reported in Beijing in 1936 (Tung and Samuel, 1936). During 1955-1978, the incidence cases of human brucellosis remained high at 0.4–1.0 cases/100,000 residents. However, the cases of brucellosis had decreased significantly from 1979 to 1994 (Lai et al., 2017). Unfortunately, brucellosis has re-emerged in the country, and the incidence of brucellosis has been increasingly concerned. (Zhong et al., 2013).

Epidemiological study of brucellosis in livestock has been observed in both herd and individual levels. In China, the pooled prevalence of brucellosis at the herd level in sheep and goat increased from 2000–2009 (1.0%; 95% C.I., 0.7%–1.3%) to 2010–2018 (3.2%; 95% C.I., 2.7%–3.6%) (Ran et al., 2018). The main reason of brucellosis spreading is the growing demand of meat products in mainland China. This led to significantly increase in the number of livestock. Meanwhile, long distance transportation of the live animals and lack of appropriate quarantine can increase the risk of human infection (Tan et al., 2015; Chen et al., 2016).

The Chinese government pays great attention to the prevention and control of brucellosis. Since 1950, the governmental officers at all levels gradually implemented comprehensive prevention and control strategies towards brucellosis in mainland China (Shang, 2000). From 1950 to 1963, human brucellosis reporting system was established nationwide (Deqiu et al., 2002). During 1964-1976, the vaccination against *Brucella* spp. for humans and animals was the main control of brucellosis, which was implemented in Inner Mongolia, Xinjiang, Qinghai, Ningxia, and Henan provinces (Deqiu et al., 2002). During 1977-1988, a national brucellosis control plan was applied, and all aspects of case definition, clinical features, case definition, laboratory examination criteria, treatment options, and control measures have been clarified. Since 1990, sentinel surveillance using sero-prevalence of brucellosis in

humans and animals has been included in the national brucellosis control program (Senlin et al., 2002). In 2012, the National medium- to long-term plan from 2012-2020 for animal epidemic prevention and control (2012-2020) was issued by the State Council. Based on the national action plan for control and prevention of brucellosis, this disease was listed as a priority for zoonosis (Council, 2012). In 2016, the Ministry of Agriculture and the Ministry of Health of China jointly formulated and implemented the brucellosis prevention and control plan and regarded curbing the spread of brucellosis and achieving brucellosis purification as the ultimate goals (MARA, 2016). In this plan, the central government decided to implement compulsory vaccination against brucellosis in livestock within 15 northern provinces including Beijing, Tianjin, Hebei, Shanxi, Inner-Mongolia, Liaoning, Jilin, Heilongjiang, Shandong, Henan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. This vaccination program targeted on cattle, sheep, and goats in addition to breeding and dairy animals. This compulsory vaccination program has been carried out once a year by community animal health staff at county level. In addition, three *Brucella* live vaccines have been used in China for prevention and control of brucellosis, which are strain A19 (for cattle), M5 (for sheep, goat, and cattle) and S2 (for sheep, goat, cattle, and pig). Although the use of live vaccines can significantly reduce the prevalence of brucellosis in livestock, it is undeniable that these live vaccines also pose a serious threat to human health, especially in farmers and community animal health staff.

5. Situation of brucellosis KAP research

A number of studies on KAP related to brucellosis have been carried out in different geographical distribution, including in Africa, Central Asia, and the Middle East. The previous study conducted in Kenya showed that the farmers' awareness and knowledge of brucellosis transmission routes from animals to humans were very limited (Kang'Ethe et al., 2007). Likewise, a study in the small-scale dairy farms in Tajikistan showed that poor knowledge and frequent high-risk behaviors of the farmers were observed (Lindahl et al., 2015). Another study was conducted in

Pakistan emphasized that the participants with no professional education have not heard of brucellosis and displayed greater risk behavior than those who had higher education (Arif et al., 2017). The lack of knowledge of brucellosis transmission led to high-risk behaviors being widespread practices such as dropping contaminated aborted tissues into water canals, assisting parturition without personal protective equipment, and reluctance performing to remove aborted animals from the flocks or herds (Hegazy et al., 2015). This finding contrasted to previous study indicated that inconsistency between the level of knowledge and high-risk behavior (Holt et al., 2011). Another case-control study revealed that animal husbandry, proceeding and ingestion of contaminated milk and dairy products were significantly associated with the occurrence of brucellosis cases compared to controls (Abd El-Wahab et al., 2019). The previous study also showed the barrier for notification of animal infection and/or abortion was significantly higher among cases (p = 0.034) than the controls, and this barrier correlated with participants' education (Abd El-Wahab et al., 2019). In addition, multivariate conditional logistic regression model showed the significant indicators of having brucellosis infection were ingestion of unpasteurized milk, dairy products, yoghurt or homemade cheeses in the last three months, and involvement in contact with animals (Abd El-Wahab et al., 2019).

Chapter III Materials and methods

This study was divided into 2 phases. Phase 1: Design and develop research questionnaires for field investigation, and phase 2: Questionnaire interviews and data analysis (Figure 1).

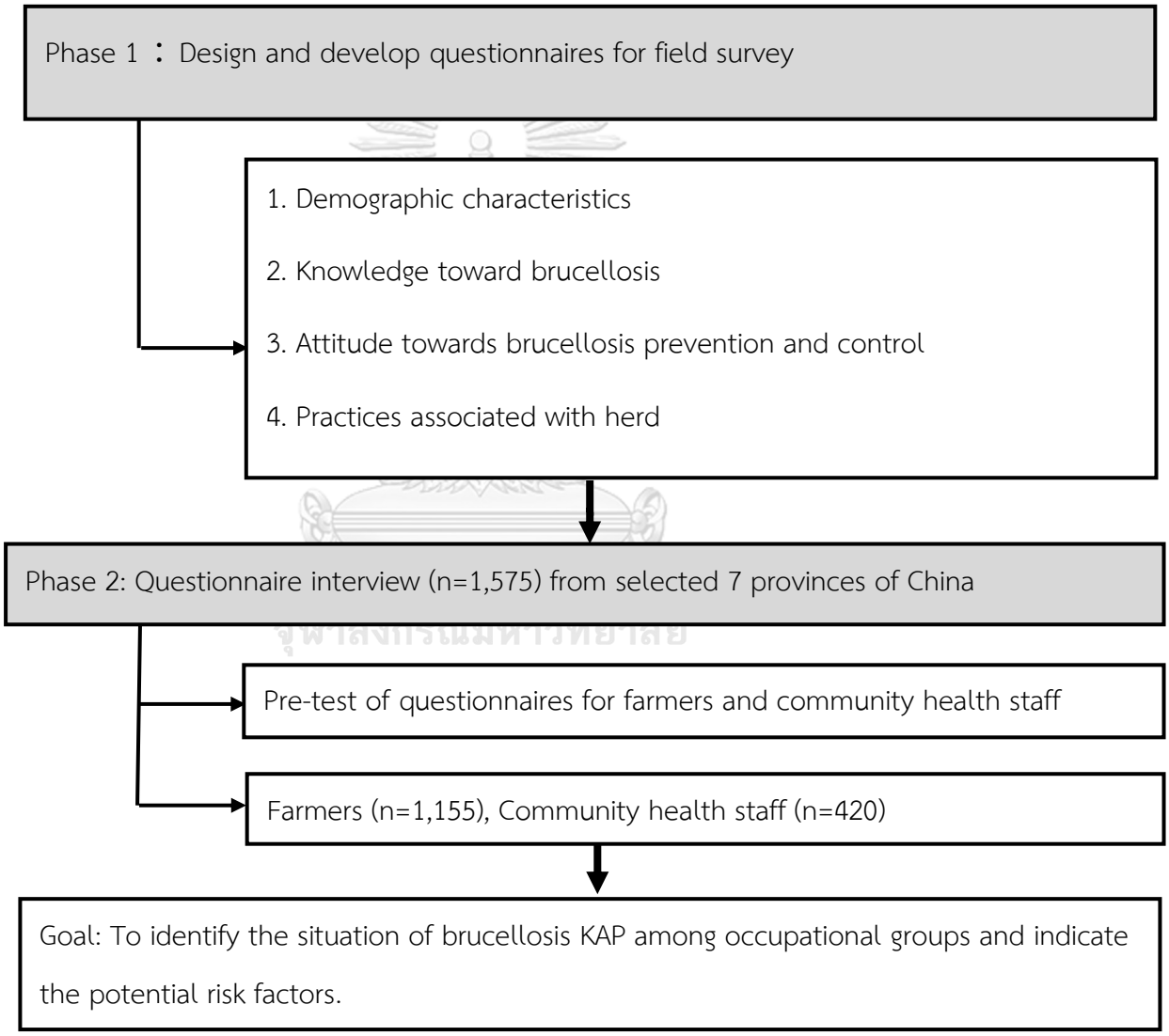

Figure 1. Conceptual framework

Phase 1: Questionnaire design

Two structured KAP questionnaires with approximately 30 questions on demographic characteristics, knowledge, attitudes, and practices relating to brucellosis were developed for sheep and goat farmers and community animal health staff. Most of the questions are multiple choice questions. The questionnaire comprised five parts: 1. demographic characteristics, 2. knowledge toward brucellosis, 3. attitude towards brucellosis prevention and control, 4. practices associated with herd management, respectively, and 5. media information associated with brucellosis.

The first part of demographic characteristics included age, marital status, educational level, working experience, etc. The second part of brucellosis knowledge, including clinical signs and potential routes of disease transmission. The third and the fourth part were attitudes towards brucellosis prevention and control and major practices associated with herd management. The last part of media related to brucellosis was designed to retrieve the feedback from the participants.

All questions were verified before performing pre-tests of 20 farmers and 10 community animal health staff in Shandong province. After that, the questionnaires were adjusted according to the questions exposed in the pre-test.

Phase 2: Questionnaire interview

1. Study area

Seven provinces, including Inner-Mongolia, Xinjiang, Shaanxi, Shanxi, Henan, Guizhou, and Guangxi were selected based on a high density of sheep and goats (NBS, 2018). The population of sheep and goats in China were 297 million heads in 2018. Specifically, the number of sheep and goats observed in the 7 provinces is accounted for 48%, which was the majority of sheep and goat populations in China. The study location was showed in Figure 2.

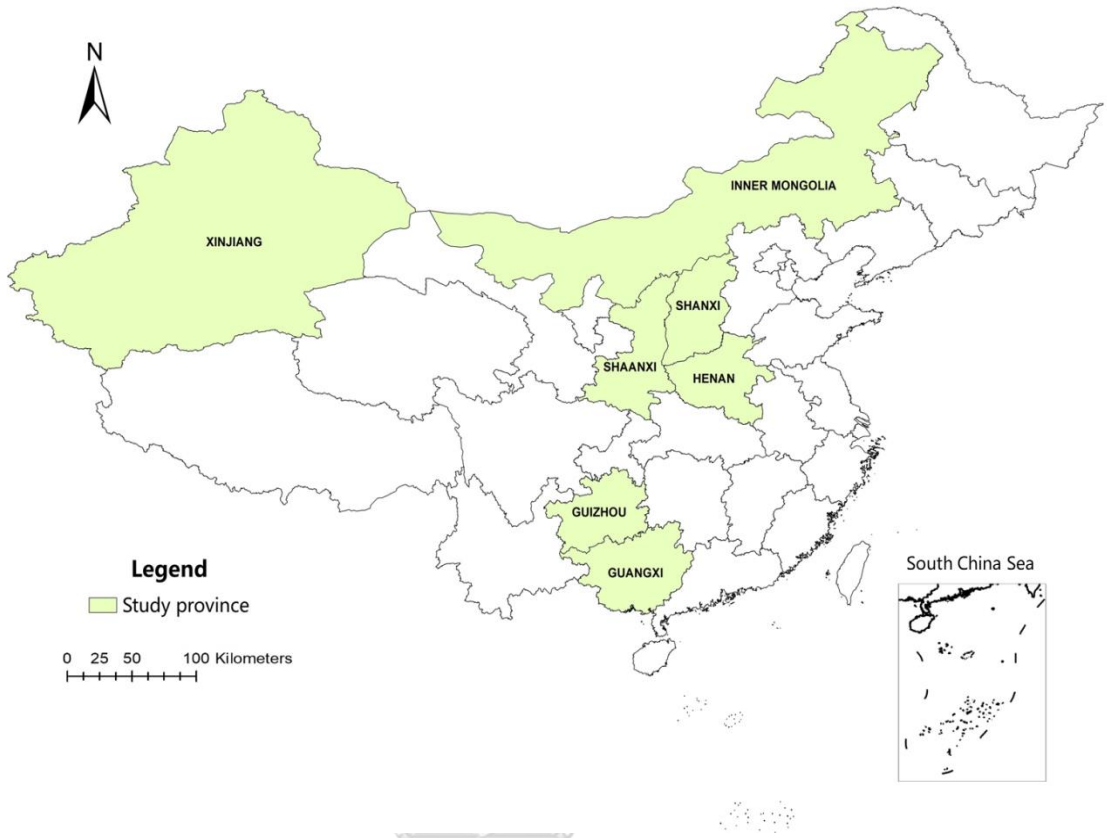

Figure 2. Map of China indicating current study areas (using ArcGIS software by Esri)

2. Study populations

The study populations are sheep and goat farmers and the community animal health staff in the selected areas. The sheep and goat farmers were people who engaged in raising sheep or goats, while the community health staffs were veterinarians or other animal health staff employed by the government to provide vaccination, diagnosis, treatment, and other services for farmers.

The inclusion and exclusion criteria were used to select the participant into this study. The inclusion criteria of sheep and goat farmers were the ones who have more than two sheep or goats. For the inclusion criteria of community health staff, the targeted staff engage in animal health related work in the community during the survey period and can speak Chinese fluently. The exclusion criteria were farmers and community health staff that resided outside seven province of study area.

3. Sample size determination

The sample size of this cross-sectional survey was calculated based on the expected awareness rate (30% for farmers and 60% for animal health staff), 95% confidence interval and 5% desired precision (Xue-feng et al., 2015; Ning et al., 2018). The sample calculation was separately calculated for farmers and animal health staff. A total sample size was 896 of sheep and goat farmers and 256 of community animal health staff. Assuming the questionnaire recovery rate is 80%, so the number of participants was adjusted, so total samples of sheep and goat farmers and community animal health staff were at least 1,120 and 320, respectively. Therefore, the grand total sample size was at least 1,440. Convenient sampling was used to select approximately 55 sheep and goat farmers and 20 community animal staffs per county. Therefore, 1,155 questionnaires were used for sheep and goat farmers and 420 questionnaires were used for community animal health staff.

4. Field survey procedure

The interview was performed orally at site visits in the households. The interview team includes four people from CAHEC, and two people from CADC. In addition, 10-15 staff from the local veterinary station also joined as investigators in each county. All investigators were received training by CAHEC before starting data collection.

5. Ethical approval

The research protocol was approved by CAHEC of Ministry of Agriculture and Rural Affairs (CAHEC-ES-2018-001). The questionnaire survey received ethics approval from the Division of Epidemiology Survey within CAHEC. All participants signed a written informed consent when they were informed on the purpose and procedures of the study. If any participants did not clearly understand mandarin Chinese, the investigators from the local veterinary station explained in local language. All data collected in the study were anonymized prior to perform statistical analysis.

6. Statistical analysis

Data management such as data entering, data cleaning was performed before data transfer. Descriptive statistics were used to explore the demographic characteristics and KAP. Total score of KAP of each respondent were converted into percentage. Mann-Whitney U test was used to analyze the potential risk factors associated with brucellosis of KAP among sheep and goat farmers and the community animal health staff. The hypothesis testing was set at two-sided with the significant level set at 0.05. Statistical analyses were conducted in SPSS version 20.0 (IBM Corp, Armonk, NY, USA).

Chapter IV Results

1. Demographical distribution and KAP of sheep and goat farmers

A total of 1,067 valid questionnaires were collected from the sheep and goat farmers with a recovery rate of 92.4 % (1,067/1,155). The overall KAP awareness rate of brucellosis prevention and control in the farmers was 64.2%.

1.1 Demographic characteristics of sheep and goat farmers

Among all the households, 92% of these farmers were married men responsible for daily management of the sheep or goats, and most of them were in the 46-60 years old. More than 80% of the households comprised of 1-5 family members. Approximately, 26.7% of the participants had primary school, 53.4% had junior middle school education, and only 19.9% had senior high school or above. The majority of respondents (>80%) had no religious beliefs. Most of the participants (58.3%) had more than five years of sheep or goats raising experience (Table 1).

Table 1. Demographic features of sheep and goat farmers participating in the survey

Variables	Frequency (%)
Gender (N=928)	
Male	854 (92.0)
Female	74 (8.0)
Age (years) (N=1,067)	
18-30	37 (3.5)
31-45	322 (30.2)
46-60	559 (52.4)
> 60	149 (14.0)
Marital status (N=1,010)	
Married	979 (96.9)
Unmarried	31 (3.1)

Table 1. Demographic features of sheep and goat farmers participating in the survey (continue)

Variables	Frequency (%)
Number of family member (N=1,057)	
1-5	868 (82.0)
6-10	186 (17.7)
> 10	3 (0.3)
Educational level (N=1,015)	
Primary school	271 (26.7)
Junior middle school	542 (53.4)
Senior high school	172 (16.9)
College or above	30 (3.0)
Religious belief (N=925)	
Buddhism	52 (5.6)
Islam	89 (9.6)
Catholicism	12 (1.3)
Others	18 (1.9)
No	754 (81.5)
Experience (N=1,067)	
≤ 5 years	462 (41.7)
> 5 years	605 (58.3)
Family members ever been infected (N=951)	
Yes	138 (14.5)
No	813 (85.5)
Sheep and goats have ever been infected (N=1,034)	
Yes	187 (18.1)
No	522 (50.5)
Not clear	325 (31.4)

Note: N specified because of missing data.

1.2 Knowledge of brucellosis of sheep and goat farmers

The majority (82.8%) of sheep and goat farmers had heard about brucellosis. However, the overall awareness of brucellosis knowledge in sheep and goat farmers was 62.6% (Table 2). The respondents believed that goat and sheep could be infected with brucellosis was high at 78.4%, followed by cattle (64.5%), pigs (26.9%), and dogs (11.9%). Most of the respondents (72.4%) randomly discarded aborted fetuses that would lead to brucellosis infected in sheep and goat. The awareness rate of non-quarantine after introduction of new sheep or goats to the farms was at 65.5%. Based on the symptoms of sheep and goat infected with brucellosis, the highest observed symptom was abortion (77.6%), followed by orchitis (66.4%), placenta retention (63.1%), and joint swelling (62.0%).

The farmers addressed that common route of human infection with brucellosis were the contact with aborted fetus (77.2%), followed by consumption of raw meat (64.7%), ingestion of raw milk (56.3%), the contact with fur (51.3%), and respiratory transmission (49.5%), respectively. The awareness rate of brucellosis symptoms in human was very close to the farmers' recognition rate of that in sheep and goats, and the asthenia symptoms was accounted for 72.3%, which was a highest proportion.

Table 2. The proportion of brucellosis knowledge awareness among sheep and goat farmers

Variables	Frequency (%)
Heard of brucellosis	
Yes	883 (82.8)
No	184 (17.2)
Could be infected with brucellosis*	
Cattle	688 (64.5)
Sheep and goat	837 (78.4)
Pig	287 (26.9)
Dog	127 (11.9)

Note: *Multiple answers allowed.

Table 2. The proportion of brucellosis knowledge awareness among sheep and goat farmers (continue)

Variables	Frequency (%)
Brucella can spread from animal to human	
Yes	772 (72.4)
No	295 (27.6)
Route of sheep and goat infected with brucellosis*	
Feeding with sick sheep	743 (69.6)
Unquarantined	699 (65.5)
Randomly discard aborted fetuses	773 (72.4)
Not disinfected of lambing areas	726 (68.0)
Symptoms of sheep and goat infected with brucellosis*	
Abortion of female sheep & goat	828 (77.6)
Placenta retention	673 (63.1)
Orchitis of male sheep & goat	709 (66.4)
Joint swelling	662 (62.0)
Route of human infected with brucellosis*	
Contact with aborted fetus	824 (77.2)
Contact with fur	547 (51.3)
Ingestion of raw milk	601 (56.3)
Eat raw meat	690 (64.7)
Respiratory transmission	528 (49.5)

Table 2. The proportion of brucellosis knowledge awareness among sheep and goat farmers (continue)

Variables	Frequency (%)
Symptoms of human infected with brucellosis*	
Fever	744 (69.7)
Sweating	692 (64.9)
Asthenia	771 (72.3)
Joint pain	743 (69.6)
Myalgia	658 (61.7)
Brucellosis can be prevented	
Yes	704 (66.0)
No	363 (34.0)
Overall knowledge awareness rate	**62.6**

Note: *Multiple answers allowed.

1.3 Attitudes of brucellosis of sheep and goat farmers

Approximately, 75.8% participants had a positive attitude towards the prevention and control of brucellosis. The majority of respondents believed that brucellosis was a serious threat to the herds (71.5%), sheep and goats need to be vaccination (77.0%), brucellosis should be prevented and controlled (77.3%), and they agreed to accept the disease prevention and control information (77.7%) (Table 3).

Table 3. Attitudes regarding brucellosis in sheep and goat farmers

Topics	Frequency (%)
Brucellosis seriously harms the health of sheep and goats	763 (71.5)
Need to prevent human brucellosis	804 (75.4)
Need to prevent sheep and goat brucellosis	825 (77.3)
Sheep and goats need to be vaccination	822 (77.0)
Accept information on brucellosis prevention and control	829 (77.7)
Overall positive attitude rate	**75.8**

1.4 Herd management practices of sheep and goat farmers

More than half of respondents (54.2%) had good behavioral habits for prevention and control of brucellosis. According to the engagement of daily management, the frequency of using mask, gloves, and rubber shoes, at work was more than 60%. However, only one third of sheep and goat farmers wore protective glasses during working. More than 60% of them adopted safety disposal of aborted fetal placenta and dead carcass. Only 42.5% of farmers quarantined new animals before flock mixed. About one third of the farmers separately used knife and cutting board for raw and cooked at home (Table 4).

Table 4. Herd management practices of sheep and goat farmers

Practices	Frequency (%)
Protective equipment used at work*	
Mask	668 (62.6)
Rubber gloves	674 (63.2)
Rubber shoes	692 (64.9)
Protective clothing	549 (51.5)
Protective glasses	392 (36.7)
Wash hands after working in sheepfold	785 (73.6)
Safety disposal of the dead sheep or goat	729 (68.3)
Safety disposal of aborted fetal placenta	671 (62.9)
Quarantined before flock mixed	454 (42.5)
Separated raw and cooked cutting board	374 (35.1)
Separated raw and cooked knives	367 (34.4)
Overall good behavior rate	**54.2**

Note: *Multiple answers allowed.

1.5 Access to brucellosis prevention and control information

The access of the information of brucellosis prevention and control was divided into two categories, which is comprised current and future access of brucellosis information. The current source of knowledge of brucellosis prevention and control obtained by sheep and goat farmers mainly from veterinary (79.7%) and traditional publicity materials (60.1%). Regarding to the acquisition of information of brucellosis in the future, veterinarians and traditional promotional materials remain the main channels, although the proportion of veterinarians decreased by 5.1%. The trend of the route of media access was TV (53.0%), followed by internet or social network (36.5%) and radio (32.2%) (Table 5).

Table 5. Access to brucellosis information of sheep and goat farmers

Source of media	Status of information accession	
	Current access	Future access
	N (%)	N (%)
Relatives and friends	299 (28.0)	279 (26.1)
Broadcast	152 (14.2)	344 (32.2)
Social network	200 (18.7)	389 (36.5)
Television	291 (27.3)	566 (53.0)
Traditional publicity materials	641 (60.1)	776 (72.7)
Veterinarians	850 (79.7)	796 (74.6)

2. KAP of community animal health staff

A total of 401 questionnaires were collected from the community animal health staff with the recovery rate was 95.5% (401/420). The overall percentage of awareness was 80.1%. However, 12.2% (49/401) of them had never heard of brucellosis.

2.1 Demographic characteristics of community animal health staff

Among all the community animal health staff, 75.8% were male, and their ages were mainly 30-45 years (44.9%), followed by 46-60 years (37.4%). Approximately, 73.0% of the respondents had college degree or bachelor degree (Table 6).

Table 6. Demographic characteristics of community animal health staff

Variables	Frequency (%)
Gender (N=363)	
Male	275 (75.8)
Female	88 (24.2)

Table 6. Demographic characteristics of community animal health staff (continue)

Variables	Frequency (%)
Age (years) (N=401)	
< 30	41 (10.2)
30-45	180 (44.9)
46-60	150 (37.4)
>60	30 (7.5)
Education level (N=370)	
Junior middle school or below	18 (4.9)
Senior high school	78 (21.1)
College or university	274 (73.0)
Have you ever heard of brucellosis? (N=401)	
Yes	352 (87.8)
No	49 (12.2)
Family members have ever been infected (N=358)	
Yes	14 (3.9)
No	344 (96.1)

Note: N specified because of missing data.

2.2 Knowledge of brucellosis of community animal health staff

The overall awareness regarding to brucellosis knowledge in community animal health staff was 79.0%. About 84.5% of the participants agreed that infected livestock with *Brucella* spp. can be transmitted to humans. The lowest awareness rate was observed in various animals can be infected with brucellosis, and only 56.4% and 29.9% of the respondents knew that brucellosis can be infected by pigs and dogs, respectively. The staff had a good understanding of the infection route of brucellosis in sheep and goat, and the awareness rate of each route was more than 80%. Among the symptoms of brucellosis infection in sheep and goat, the symptoms of abortion were the most well-known (87.3%). The community animal health staff

addressed that common route of human infection with brucellosis were the contact with aborted fetus (86.5%), In the route of human infection with brucellosis, the cognitive proportion of contact with aborted fetus was the highest (86.5%). And asthenia (86.5%) was the most commonly known symptom of brucellosis in human (Table 7).

Table 7. Community animal health staffs' awareness of brucellosis knowledge

Variables	Frequency (%)
Which animals can be infected with brucellosis?*	
Cattle	336 (83.8)
Sheep and goat	345 (86.0)
Pig	226 (56.4)
Dog	120 (29.9)
Livestock brucellosis can be transmitted to humans	339 (84.5)
Sheep and goat infected route*	
Feeding with sick sheep	339 (84.5)
Unquarantine	343 (85.5)
Randomly discard aborted fetuses	340 (84.8)
Not disinfected of lambing areas	334 (83.3)
Symptoms of sheep and goat infected with brucellosis*	
Abortion of female sheep & goat	350 (87.3)
Placenta retention	307 (76.6)
Orchitis of male sheep & goat	328 (81.8)
Joint swelling	313 (78.1)

Note: *Multiple answers allowed.

Table 7. Community animal health staffs' awareness of brucellosis knowledge (continue)

Variables	Frequency (%)
Route of human infected with brucellosis*	
Contact with aborted fetus	347 (86.5)
Contact with fur	306 (76.3)
Ingestion of raw milk	321 (80.0)
Eat raw meat	339 (84.5)
Respiratory transmission	283 (70.6)
Symptoms of human infected with brucellosis*	
Fever	338 (84.3)
Sweating	330 (82.3)
Asthenia	347 (86.5)
Joint pain	339 (84.5)
Myalgia	302 (75.3)
Brucellosis can be prevented	334 (83.3)
Overall awareness rate	**79.0**

Note: *Multiple answers allowed.

2.3 Attitudes of community animal health staff towards brucellosis prevention and control

Most of community animal health staff (83.8%) had positive attitude towards the brucellosis prevention and control (Table 8). Most of the community health staff had attitude rate toward brucellosis control and prevention was approximately 80%. Specifically, those who think that sheep and goat need to carry out brucellosis vaccination, need to prevent human brucellosis, need to prevent livestock brucellosis, agree that brucellosis is seriously harmful to sheep and goat, and eager to receive brucellosis prevention information accounted for 85.3%, 81.5%, 85.0%, 81.3% and 85.8%, respectively.

Table 8. Attitudes regarding brucellosis in community animal health staff

Topics	Frequency (%)
Sheep and goats need to be vaccination	342 (85.3)
Need to prevent human brucellosis	327 (81.5)
Need to prevent livestock brucellosis	341 (85.0)
Brucellosis seriously harms the health of sheep and goats	326 (81.3)
Eager to receive brucellosis prevention and control information	344 (85.8)
Overall positive attitude rate	**83.8**

2.4 Behaviors of community animal health staff towards brucellosis prevention and control

Approximately, 77.6% of community animal health staff had proper habits in the management of brucellosis prevention and control. More than 75% were equipped with personal protective equipment while working. About 60% of respondents can separate raw and cooked kitchen knives (Table 9).

Table 9. Brucellosis prevention and control practices among animal health staff

Practices	Frequency (%)
Whether to use these tools during brucellosis prevention and control*	
Mask	343 (85.5)
Rubber gloves	341 (85.0)
Rubber shoes	340 (84.8)
Protective clothing	336 (83.8)
Protective glasses	300 (74.8)

Note: *Multiple answers allowed.

Table 9. Brucellosis prevention and control practices among animal health staff (continue)

Practices	Frequency (%)
Whether to use these tools during brucellosis prevention and control*	
Mask	343 (85.5)
Rubber gloves	341 (85.0)
Rubber shoes	340 (84.8)
Protective clothing	336 (83.8)
Protective glasses	300 (74.8)
Wash hands after finishing the work in the sheep and goat enclosure	347 (86.5)
Kitchen knives are raw and cooked separately	243 (60.6)
Separate the raw and cooked chopping board	241 (60.1)
Overall good behavior rate	**77.6**

Note: *Multiple answers allowed.

2.5 Access to brucellosis prevention and control information of community animal health staff

At present, the knowledge of brucellosis prevention and control acquired by community animal health staff mainly came from the experts and traditional publicity materials, which were accounted for 80.8% and 76.8%, respectively. In the future, although the proportion of the experts provide the knowledge had dropped by 11.7%, the information from the experts were still the most important way to spread knowledge of brucellosis together with traditional publicity materials. Among other sources of information, the trend of using internet and television to receive knowledge regarding to brucellosis increased from 42.6% and 34.9% to 69.3% and 65.8%, respectively. The proportion of receiving brucellosis information through radio rose up to 47.9% (Table 10).

Table 10. Access to brucellosis information of community animal health staff

Source of media	Status of information accession	
	Current access	Future access
	N (%)	N (%)
Relatives and friends	82 (20.4)	98 (24.4)
Broadcast	91 (22.7)	192 (47.9)
Television	140 (34.9)	264 (65.8)
Experts	324 (80.8)	277 (69.1)
Network	171 (42.6)	278 (69.3)
Traditional publicity materials	308 (76.8)	313 (78.1)

3. Potential factors affecting KAP awareness

3.1 Potential factors affecting the KAP of sheep and goat farmers

The results showed were location of sampling (northern or southern provinces), the sheep and goats had ever been infected with brucellosis, age of respondents, educational level, and experience of rearing sheep and goat were significant factors associated with KAP. Farmers from northern province, with age under 45 years old, educated at junior high school level or above, experienced less than 5 years, and had experience of animals in his/her farms infected with brucellosis in flocks, had a higher level of KAP (Table 11).

Table 11. Potential factors affecting brucellosis KAP awareness of sheep and goat farmers

Variables	N	Median KAP score	*p*
Region			
Northern province	847 (79.4)	75.0	<0.001
Southern province	220 (20.6)	62.5	

Table 11. Potential factors affecting brucellosis KAP awareness of sheep and goat farmers (continue)

Variables	N	Median KAP score	*p*
Flock had ever infected			
Yes	187 (17.5)	80.0	<0.001
No/Not clear	846 (82.5)	70.0	
Age (year)			
≤45	359 (33.6)	77.5	0.002
>45	708 (66.4)	70.0	
Education level			
≤Primary school	271 (26.7)	67.5	0.001
≥Junior high school	744 (73.3)	75.0	
Experience			
≤5 years	462 (41.7)	77.5	0.028
>5 years	605 (58.3)	70.0	
Family member had ever infected			
Yes	138 (14.5)	70.0	0.971
No	813 (85.5)	75.0	
Gender			
Male	854 (92.0)	72.5	0.855
Female	74 (8.0)	77.5	

3.2 Potential factors affecting KAP of community animal health staff

The results showed that the KAP of community animal health staff was significantly associated with the educational level. The participants who with college education or above had a higher KAP scores than those received lower educational levels. Other factors such as region, age and history of family members infected with brucellosis were no statistically significant difference related to the KAP (Table 12).

Table 12. Potential factors affecting brucellosis KAP awareness of community animal health staff

Variables	N (%)	Median KAP score	*p*
Education level			
≤Junior high school	96 (25.9)	87.8	<0.001
≥College degree	274 (74.1)	91.9	
Region			
Northern province	308 (76.9)	91.9	0.132
Southern province	93 (23.1)	91.9	
Age (year)			
≤45	221 (55.1)	91.9	0.806
>45	180 (44.9)	91.9	
Family member had ever infected			
Yes	14 (3.9)	91.9	0.927
No	344 (96.1)	91.9	
Gender			
Male	275 (75.8)	91.9	0.668
Female	88 (24.2)	91.9	

Chapter V Discussion

This study assessed the KAP of sheep and goat farmers and community animal health staff regarding brucellosis in the selected seven provinces in China. To our knowledge, this is the first study conducted on the occupational risk groups' knowledge and awareness about brucellosis in such a large-scale epidemiological study in China. This study emphasized the potential prevention and control to reduce the risk of the occupational risk groups acquiring the disease, as well as providing useful information for the implementation of prevention and control strategies against brucellosis in both humans and livestock.

The study findings clearly showed that most of the sheep and goat farmers (82.8%) and community animal health staff (87.8%) had heard about brucellosis, which agrees with the previous studies in Jordan, Egypt, and Uganda (Holt et al., 2011; Kansiime et al., 2014; Musallam et al., 2015). However, the knowledge and awareness regarding brucellosis transmission, clinical symptoms and prevention was limited compared with the brucellosis heard rate.

The overall awareness of brucellosis on KAP of the farmers and animal health staff was 64.2% and 80.1%, respectively. Similar findings were reported from Kenya and Tajikistan that there was a low awareness rate observed among farmers (Kang'Ethe et al., 2007; Lindahl et al., 2015). The low awareness of brucellosis in this study could be attributed the low proportion of farmers receiving formal education on brucellosis. Although more than 70% of the farmers aware of brucellosis is zoonoses, of which these respondents knew the infected route of brucellosis in animals (68.9%) was higher than that of humans (59.8%). Several studies highlighted that having a good knowledge about disease transmission was not confirmed that they are more likely to perform proper practices to avoid contracting with *Brucella* spp.

The study in the Kyrgyz Republic stated that good knowledge about disease transmission routes for brucellosis of farmers had a precautionary effect for brucellosis (Kozukeev et al., 2006). In a similar way, a case control study in Iran demonstrated that having awareness regarding modes of brucellosis transmission, i.e.

consumption of raw milk cheese was associated with a risk reduction of human brucellosis (Sofian et al., 2008). This suggests that improving farmers' knowledge of the disease and mode of transmission were likely to reduce the risk of brucellosis transmission from animals.

The majority of sheep and goat farmers and community animal health staff had a general positive attitude regarding brucellosis prevention and control. More than 75.8% and 83.8% of them believed that human and animal brucellosis should be prevented and controlled, and they were willing to immunize their livestock and receipt more knowledge about brucellosis. Similar studies carried out in Sri Lanka and Northern Uganda reported that health workers tended to have positive attitude towards control and prevention of brucellosis (Nabirye et al., 2017; Kothalawala et al., 2018). This finding of this study would highly benefit to implement any control and prevention strategies of brucellosis. The involvement of livestock producers is critical for effective disease intervention (Ritter et al., 2017). However, the good attitude did not correspond to good practices among the farmers (54.1%) and animal health staff (77.6%). The improper practices found in this study were a great risk for human infection (Nabirye et al., 2017). This study revealed that the farmer's protective practices of brucellosis were inadequate, only two fifth of farmers quarantined their newly bought sheep and goats before flock mixed. This behavior has been previously described as one of the most important risk factors causing sheep and goat infection (Liu et al., 2020).

Another important improper practice was that knives and boards for cutting raw and cooked meat at home were not used separately. In this study, only one third of farmers separated raw and cooked knives and cutting boards. In addition, more than one third of farmers did not treat the contaminated fetus and placenta of aborted sheep or goats before disposal. Similar result was supported by previous study (Musallam et al., 2015). As brucellosis can be directly transmitted from aborted fetuses and discharges to humans, this practice would increase the risk of human infection of brucellosis (Earhart et al., 2009). This study revealed that the participants with higher education level had good practices than those who carried low education. These findings are supported by a previous study that the participants

with higher education level showed good practices in prevention and control of brucellosis (Arif et al., 2017).

Based on the Mann-Whitney U test, the farmers who resided in northern areas, had age less than 45 years, had education higher than junior high school, experienced less than 5 years and their sheep or goat ever infected with brucellosis had higher KAP scores than others ($p < 0.05$). Community animal health staffs, who had lower education, had lower KAP scores than those had higher education ($p < 0.01$). The awareness of sheep and goat farmers and local veterinary staffs still needs to be efficiently improved and strengthened. Not surprisingly, the level of education received is an important factor that could positively influence a person's ability and inclination to acquire further knowledge (Mohamed et al., 2017). In this study, all participants who had obtained a high level of education, had a better KAP awareness. This is a vital component of prevention and control of the disease in animals (Dlamini et al., 2017). Other studies have similarly shown that farmers with a lower level of education were less likely to have knowledge about brucellosis (Lindahl et al., 2015), and were more likely to acquire the disease (Al-Shamahy et al., 2000).

For the farmers, the overall awareness of respondents resided in the northern area was significantly higher than that in the southern areas. That is because brucellosis has been commonly reported in northern China for a long period of time (Zhong et al., 2013). At the same time, the government has made great efforts to control brucellosis. Farmers under the age of 45 with less than 5 years of experiences meant that they were younger and had better education, which would also provide them more opportunity to easily access to educational materials regarding to brucellosis. Additionally, whose sheep or goat have been infected with brucellosis, the farmers' KAP awareness would be better. It was easy to understand that sheep infected with brucellosis would bring property losses and pose a serious threat to family's health, which must be unforgettable for their families. This would certainly promote infected families to learn as much as possible about the prevention and control of brucellosis and avoid recurrence. For community animal health staff, 73% of them had college or university education. This was the only

factor that affected the awareness of KAP, which could also explain that community animal health staffs' KAP score was generally higher than the farmers. This result was similar to KAP studies conducted in Northern Uganda and Sudan for animal health workers, medical and community workers (Marin et al., 2017; Nabirye et al., 2017). The main source of brucellosis information reported among the farmers and animal health staff in this study was traditional publicity materials, other sources mentioned included television, radio, internet, veterinarians, and friends. These findings were similar to previous studies in South Africa, Kenya, Tajikistan, and Pakistan (Lindahl et al., 2015; Musallam et al., 2019; Tempia et al., 2019; Zhang et al., 2019). This study addressed that the previously prevention and control of brucellosis was unsatisfactory, which was mainly reflected in the participants' poor knowledge of prevention and control of brucellosis. Most of participants considered current publicity channels mainly came from experts and traditional publicity materials, which lead to low accuracy and low efficiency. With the continuous development of new media, brucellosis knowledge and health intervention could be implemented through different online platforms.

Chapter VI Conclusion and suggestions

1. The sheep and goat farmers and community animal health staff generally showed a high level of KAP awareness about brucellosis. However, knowledge and appropriate practices for brucellosis control and prevention still have plenty of room for improvement. This indicated that the government should make unremitting efforts to carry out publicity and education on brucellosis.

2. The KAP awareness rate of farmers was significantly lower than that of community animal health staff. In addition, the awareness rate in the northern areas was higher than that in the southern areas, it was suggested that the publicity of brucellosis should take into account the differences of audience groups and regions.

3. The potential factors affecting KAP included education level, age of respondents, experience in livestock production, and previous infection status of animals and their families, which require priority health intervention for farmers and community animal health staff. Especially, participants who had the characteristics of low education level, older age, and longer raising experiences should be paid more attention.

4. The farmers and community animal health staff had poor understanding of some important knowledge and preventive practices of brucellosis, such as directly mixing flock without quarantine a new goat and sheep, and randomly discarding placental membranes. Therefore, the next step of health intervention should be aimed at these cognitive blind areas to improve the educational materials, in order to minimize the impact of brucellosis on their livestock and families.

5. Traditional publicity materials and veterinary experts were still the main pathways for farmers and community animal health staff to obtain the brucellosis information, but it was neither efficient nor in line with the development trend of modern media. This is suggested that brucellosis knowledge and health intervention should be update and effectively implemented through different online platforms.

6. Health publicity and education is an important measure for disease prevention and control, but the improvement of herders' awareness and practices change was gradual and steady, and it was difficult to achieve it overnight. Therefore, it is necessary to construct a long-term mechanism of brucellosis publicity, so that the health intervention work could be carried out systematically and continuously.

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APPENDICES

Appendix A

Brucellosis KAP questionnaire for Sheep/Goat Farm/Household

Name:	Telephone:
Address:	
Part 1. Demographic characteristics	
Q1: Gender:_____ ①Male ②Female	
Q2: Age:	
Q3: Number of family member:	
Q4: Marital status:_____ ①Married ②Unmarried	
Q5: Educational level: ①Primary school or below ②Junior middle school ③Senior high school ④College or above	
Q6: Religious belief: ①Buddhism ②Islam ③Catholicism ④No ⑤Others	
Q7: Which year did you start raising sheep or goat :	
Q8: Have any of your sheep or goats ever been infected with brucellosis? ①Yes ②No ③Not clear	
Q9: Have any family members ever been infected with brucellosis? ①Yes ②No	
Part 2. Knowledge of brucellosis	
Q10: Have you ever heard of brucellosis? ①Yes ②No	
Q11: Which animals can be infected with brucellosis? ①Cattle ②Sheep and goat ③Pig ④Dog ⑤Don't know	
Q12: Do you know Brucella can be spread from animal to human? ①Yes ②No ③Don't know	

Q13: What are the following ways to spread brucellosis between sheep and goats? ①Feeding with sick sheep ②Imported sheep and goat are mixed directly without quarantine ③Randomly discard aborted fetuses ④Not disinfected of lambing areas
Q14: Do you know what symptoms sheep and goat will have when they infected with brucellosis? ①Abortion of female sheep & goat ②Placenta retention ③Orchitic of male sheep & goat ④Joint swelling
Q15: Which of the following activities may lead to human infected with brucellosis? ①Contact with aborted fetus ②Contact with fur ③Ingestion of raw milk ④Eat raw meat ⑤Respiratory transmission
Q16: Do you know what symptoms human will have when they infected with brucellosis? ①Fever ②Sweating ③Asthenia ④Joint pain ⑤Myalgia
Q17: Do you think brucellosis can be prevented and controlled? ①Yes ②No ③Don't know
Part 3. Attitude towards brucellosis
Q18: Do you think brucellosis seriously harms the health of sheep and goats? ①Yes ②No ③Don't know
Q19: Is it necessary to prevent human brucellosis? ①Yes ②No ③Don't know
Q20: Is it necessary to prevent sheep and goats brucellosis? ①Yes ②No ③Don't know
Q21: Do you think sheep and goat need to be vaccinated against brucellosis?

①Yes ②No ③Don't know
Q22: Are you willing to accept information on brucellosis prevention and control? ①Yes ②No
Part 4. Herd management practices towards brucellosis
Q23: Do you use protective equipment as follows when you engaged in the prevention and control of brucellosis? Mask ①Yes ②No Rubber gloves ①Yes ②No Rubber shoes ①Yes ②No Protective clothing ①Yes ②No Protective glasses ①Yes ②No
Q24: Do you wash your hands after finishing the work in the sheep and goat enclosure? ①Yes ②No
Q25: What do you do with your sheep or goats when they die? ①Safety disposal ②Sell out ③Feed the dog ④Randomly discard
Q26: How do you deal with the fetus placenta after sheep or goat abortion? ①Safety disposal ②Edible ③Feed the dog ④Randomly discard
Q27: After the sheep or goats are introduced from outside, are they quarantined before mixing the herd? ①Yes ②No
Q28: Are the cutting boards used raw and cooked separately? ①Yes ②No
Q29: Are kitchen knives used raw and cooked separately? ①Yes ②No
Part 5. Media information
Q30: In what ways did you access the knowledge of brucellosis?

①Relatives and friends	②Broadcast
③Social network	④Television
⑤Traditional publicity materials	⑥Veterinarians

Q31: In what ways do you hope to access the knowledge of brucellosis in the future?

①Relatives and friends	②Broadcast
③Social network	④Television
⑤Traditional publicity materials	⑥Veterinarians

Thank you for your support and cooperation!

Appendix B

Brucellosis KAP questionnaire for community animal health staff

Name:	Telephone:
Address:	
Part 1. Demographic characteristics	
Q1: Gender: _____ ①Male ②Female	
Q2: Age:	
Q3: Educational level: ①Primary school or below ②Junior middle school ③Senior high school ④College or above	
Q4: Have you ever heard of brucellosis? ①Yes ②No	
Q5: Have any family members ever been infected with brucellosis? ①Yes ②No	
Part 2. Knowledge of brucellosis	
Q6: Which animals can be infected with brucellosis? ①Cattle ②Sheep and goat ③Pig ④Dog ⑤Don't know	
Q7: Do you know Brucella can be spread from animal to human? ①Yes ②No ③Don't know	
Q8: What are the following ways to spread brucellosis between sheep and goats? ①Feeding with sick sheep ②Imported sheep and goat are mixed directly without quarantine ③Randomly discard aborted fetuses ④Not disinfected of lambing areas	
Q9: Do you know what symptoms sheep and goat will have when they infected with brucellosis? ①Abortion of female sheep & goat	

②Placenta retention ③Orchitic of male sheep & goat ④Joint swelling
Q10: Which of the following activities may lead to human infected with brucellosis? ①Contact with aborted fetus ②Contact with fur ③Ingestion of raw milk ④Eat raw meat ⑤Respiratory transmission
Q11: Do you know what symptoms human will have when they infected with brucellosis? ①Fever ②Sweating ③Asthenia ④Joint pain ⑤Myalgia
Q12: Do you think brucellosis can be prevented and controlled? ①Yes ②No ③Don't know
Part 3. Attitude towards brucellosis
Q13: Do you think sheep and goat need to be vaccinated against brucellosis? ①Yes ②No ③Don't know
Q14: Do you think brucellosis seriously harms the health of sheep and goats? ①Yes ②No ③Don't know
Q15: Is it necessary to prevent human brucellosis? ①Yes ②No ③Don't know
Q16: Is it necessary to prevent sheep and goats brucellosis? ①Yes ②No ③Don't know
Q17: Are you willing to accept information on brucellosis prevention and control? ①Yes ②No
Part 4. Behaviors of local veterinary staffs towards brucellosis
Q18: Do you use protective equipment as follows when you engaged in the prevention and control of brucellosis? Mask ①Yes ②No Rubber gloves ①Yes ②No

Rubber shoes ①Yes ②No Protective clothing ①Yes ②No Protective glasses ①Yes ②No
Q19: Do you wash your hands after finishing the work in the sheep and goat enclosure? ①Yes ②No
Q20: Are the cutting boards used raw and cooked separately? ①Yes ②No
Q21: Are kitchen knives used raw and cooked separately? ①Yes ②No
Part 5. Media information
Q22: In what ways did you access the knowledge of brucellosis? ①Relatives and friends ②Broadcast ③Social network ④Television ⑤Traditional publicity materials ⑥Veterinarians Q23: In what ways do you hope to access the knowledge of brucellosis in the future? ①Relatives and friends ②Broadcast ③Social network ④Television ⑤Traditional publicity materials ⑥Veterinarians

Thank you for your support and cooperation!

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AWARD RECEIVED	No